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Comparative Study on Compressive Strength of Locally Produced Fired Clay Bricks and Stabilized Clay Bricks with Cement and Lime

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ABSTRACT

The local fired brick production technique is the known method of brick making especially in Jimma Town. Firing of bricks in local brick production method is conducted by burning of much amount of woods. But this method of firing bricks by burning of woods will affect the environment. The locale firing technique is difficult to control the firing temperature, which will result in non-uniform burnt bricks. The major objective of this experimental study was to compare the compressive strengths of locally fired clay bricks and the local unfired cement and lime stabilized clay bricks. Specifically, the index properties of soil used for brick production, the compressive strength of locally fired clay bricks and stabilized clay bricks had been determined and to compare with the standard specifications. This study, it was used contents of the stabilizer for cement and lime of 10%, 12% and 14%, respectively. The mix ratio applied 1:9, 1:7 and 1:6 by volume of clay with stabilizer 10%, 12% and 14%. Based on the result at 28th day, the mean compressive strength test, the 10%, 12% and 14% cement Stabilized clay bricks have compressive strengths of 2.91Mpa, 3.28Mpa, and 3.79Mpa respectively, which are better than the mean compressive strength of the locally fired clay bricks which is 2.73Mpa. On the other hand, the 28th day mean compressive strengths of the lime stabilized clay bricks were 2.19Mpa, 2.51Mpa and 2.69Mpa, respectively. Therefore, these results showed that the Fired Clay Brick fails the minimum mean compressive strength requirement based on the ES, ASTM and IS standards. But the Stabilized Clay Bricks fulfill the minimum compressive strength requirements of IS standard for stabilized bricks. Among these three methods, the cement stabilized clay bricks indicated better in quality than both locally fired and lime stabilized bricks.

Keywords: Cement and Lime stabilizers, Compressive Strength, Fired clay bricks, Index properties.

1 INTRODUCTION

The housing problems in Ethiopia is a very critical issue that not only its poor condition and level of affordability, but also its critical degradation of the environment. Because in the pastoral areas, villages as well as most of the towns are using wood for the construction of the houses, which lead to the environmental degradation and for high contribution to global warming. Ethiopia is like in many other developing countries; especially African countries have critical shortage and poor condition of the housing which have a significant effect on the environment. These problems can be solved through the application of engineering knowledge that the country need to stand for the whole development [1]. Clay brick is the first man made artificial building material and one of the oldest building materials known. Its widespread use is mainly due to the availability of clay in most countries. Due to inadequate resources in developing countries, cost reduction seems to be the best way forward, especially in housing for the economically weaker section. This can be achieved by innovating, manufacturing, and utilizing low cost, but durable construction materials from locally available resources. Traditional earth construction techniques such as compressed earth blocks are experiencing a new popularity, taking into account that they constitute green building materials, becoming economically competitive [2].

The production process of Fired clay bricks in Jimma town consisted of preparing the clay materials from the quarry, tempering, molding, drying and firing. Among these processes, firing is the most important for the hardening of the brick. The firing process to locally produce fired clay bricks are by using heat from burning of woods. But this has an adverse impact on the environmental condition due to high deforestation of tress. Traditional brick and tile production requires a great deal of fuel during firing. This excess fuel consumption increases air pollution. If wood is used as a fuel, excess consumption often contributes to deforestation and associated environmental impacts [3].

Soil requires to be stabilized because the materials found in its natural state are not durable for long-term use in buildings. By properly modifying the properties of soil, its long term performance can be significantly improved [4]. Soil stabilization processes focus on altering its phase structure, namely the soil–water-air interface. The general goal is to reduce the volume of interstitial voids, fill empty voids and improve bonding between the soil grains. In this way, requires mechanical method to reduce porosity, limit dimensional changes, and enhance resistance to normal and sever exposure conditions can be achieved [5].

In addition to the environmental effect, firing by a traditional way also affects the quality of the produced fired clay bricks. When Clay soil reacts with water, it becomes plastic and can be molded with different shapes. But for structural use of the produced product in addition of drying it should also be fired with a suitable temperature. The hardening process by firing of the bricks cannot be controlled by the traditional way of production of bricks. Therefore, this uncontrolled burning process results after burning or under burning of the bricks with lower qualities in both cases. This research study applied the concept of stabilizing the clay soil with cement and lime to provide the hardness of the bricks by chemical action as well as fired brick clay. Firing the bricks creates a ceramic bond in a specific temperature (900ºc -1200ºc) which increases the strength of brick making it water resistant. Using the right amount of fuel is very important not only for fuel and cost efficiency but also to provide the right temperature for bonding. Low temperature results in poor quality /bonding while high temperature would either slump or melt the bricks [6].

2 RESEARCH METHODOLOGY

2.1. Materials

The materials used in this research are soils from MURTESA local brick production small and micro enterprise; Dangote Cement used in the stabilization process (42.5R ordinary Portland cement); and hydrated lime ($Ca(OH)2$) from Dire Dawa cement and lime factory. While, the water used in this study was a potable tap water from MURTESA local brick production small and micro enterprise water supply system.

2.2. Preparation of Materials

Clay soil was excavated by using hand tools and collected on the plastic cover and air dried for one week. This was done to remove the moisture, and to make it easy for grinding. After air drying the grinding was undertaken using a shovel to break the lumps in the soil. Any coarser materials were grinded into fine by hands, and any vegetation roots and stones were removed. The physical properties of the soil were determined following the given test methods in Table 1. The AASHTO Classification of the soil was determined by using the properties of the soil, which represents the percent passing Sieve no. 200, liquid limit, plastic limit and plasticity index. Then the content of stabilization had been determined by the estimated amount of cement stabilization for different AASHTO class soils based on PCA [8]. As indicated in the index properties of the soil the soil, it was A-7 clay soil with the stabilizing amount of cement 10%-14% by volume as per

Portland Cement Association estimates. In this research, it was considered 10%, 12% and 14% contents of stabilizer.

Table 1. Standards to conduct index properties of the soil

Index properties of soil				
Index property	**Moisture Content**	**Atterberg Limit**	**Grain Size**	**Linear shrinkage**
Test method	ASTM D 2216	ASTM D 4318	ASTM D 422	CTM 228 - A4

2.3. Production of Clay Bricks

The fired clay bricks for the comparison of the compressive strength and other quality tests with stabilized clay bricks were purchased from MURTESA local brick production small scale enterprise‖. Production of fired clay bricks in Jimma Town is done, first by mudding the soil by foot and then molding by hand. Followed by the so-called green bricks, which is dried about one month if it is sunny season, or 2-3 months if it is rainy season. The final step is brick firing. The firing process takes place by building up a rectangular wall like structure with 40,000-50,000 dried green bricks. The bottom part has openings to facilitate the firing process which will last for up to 3 days. Generally, the local FCB production will need at least 35 days if there are 40,000-50,000 bricks can be molded per day which is not possible to obtain.

The production of stabilized bricks in this research consisted of proportioning of materials, mixing, molding and curing. As indicated in the index properties of the soil, the clay belongs to A-7 clay soil with the stabilizing amount of cement 10%-14% by volume. The content of cement and lime were taken the same as the estimated cement content of 10%, 12% and 14%. This means, for the ratio of 10% stabilization, 90% parts was clay soil and the 10 parts was cement or lime. After mixing, it was manually compacted the molded bricks, then curing of bricks followed by using water sprinkle for one week.

2.4. Compressive Strength Test on Bricks

Compressive strength test was carried-out to determine the compressive strength of both fired and stabilized bricks in accordance with ASTM C-67. In the laboratory, the materials capped with1: 2 Ratio (by weight) of cement, sand mortar and after 24hrs, the test conducted. Before the stabilized bricks attained the ages of curing for strength test of 7th day, 14th day, and 28th day, the samples brought from the curing area to the laboratory 3 days prior to the test to be conducted, for purpose of capping on its surface. The weight of each brick was recorded before being capped by 1:2 ratios (by weight) of cement sand mortar. Before the compressive strength test conducted, the capped bricks allowed to air dry for 24 hrs. The bricks were then crushed and the corresponding failure load recorded. The crushing force was divided by the sectional area of the bricks to arrive at the compressive strength. For each day of curing, five bricks from each content of stabilizers were taken. That is 5x6 (10% cement, 12% cement, 14% cement, and 10% lime, 12% lime and 14% lime).

2.5. Sample Size and Sampreparpling Procedures

Selection of samples for this study is the purposive sample selection. The main objective of this study is to compare the compressive strength of locally produced fired clay bricks with cement-clay and lime-clay stabilized bricks by altering the contents of the stabilizing agents applied based on the type of soil. The compressive strength for all types of bricks were tested on the 7th day, 14th day and 28th day of the curing period. Other quality tests conducted on the bricks after the 28th day of curing. The total numbers of sampled clay bricks for this laboratory experiment composed of 200 bricks.

3 RESULTS AND DISCUSSION

3.1. Laboratory Test Results for the Index Properties of Soil

According to K.R. Arora, 2004, the simple test which is required to determine the index properties of soil are known as classification tests; the soils are classified and identified based on the index properties [7].

Table 2: Index properties of soil used in brick production

Index property	**Test result value**
Natural moisture content	25.30%
Percent passing (0.075mm) or no 200	44.34%
Liquid limit	48%
Plastic limit	36%
Plasticity index	12
Linear shrinkage	5.89%
Maximum dry density	1529kg/m3
Optimum moisture content	18.8T%
Specific gravity	2.77
AASHTO class	A-7

3.2. Compressive Strength of Bricks

3.2.1. Compressive strength of locally fired clay bricks

The compressive strength test of the locally fired clay bricks was conducted on locally fired clay bricks purchased from MURTESA Micro and Small Scale Local Brick Production Enterprise.

Table 3: Compressive strength result of locally fired clay bricks

Samples	1	2	3	4	5
Compressive strength result	3.47	3.76	2	3	2.2

In Table 3, it shows the compressive strength of the samples of locally fired clay bricks vary significantly from one sample to another. The samples of the locally fired clay bricks were taken randomly from the top. Bottom and middle parts of the firing stock. Since the firing wood is inserted at the opening provided at the bottom of the prepared built up for firing, the bricks at the bottom will get high heat of burning and at the top will get lower heat of burning relatively. The average compressive strength of the locally fired clay brick samples from MURTESA small scale and micro enterprise found in Jimma Town is 2.73 Mpa.

According to the study of Altayework B, 2013, regarding the effects of firing temperature on some physical properties of burnt clay bricks produced around Addis Ababa, Altayework concluded that as the firing temperature of fire clay bricks increase the compressive strength of the produced clay bricks will also increase [8]. From this, the way of production or way of burning of the green bricks locally to produce locally fired clay bricks affects the compressive strength value of the bricks because the firing temperature of the locally fired clay bricks, which decreases from the bottom to the top of the green bricks built up for firing. This clearly indicates that the quality of the locally fired clay bricks is not uniform due to the traditional firing technique.

3.2.2. Compressive strength of cement stabilized clay bricks

The compressive strength test of cement stabilized bricks was conducted in JiT Construction materials laboratory at 7th day, 14th day and 28th day of curing period as per the test method on ASTM C-67. Five cement stabilized clay brick samples for each day of curing with cement content of 10%, 12% and 14% were undertaken.

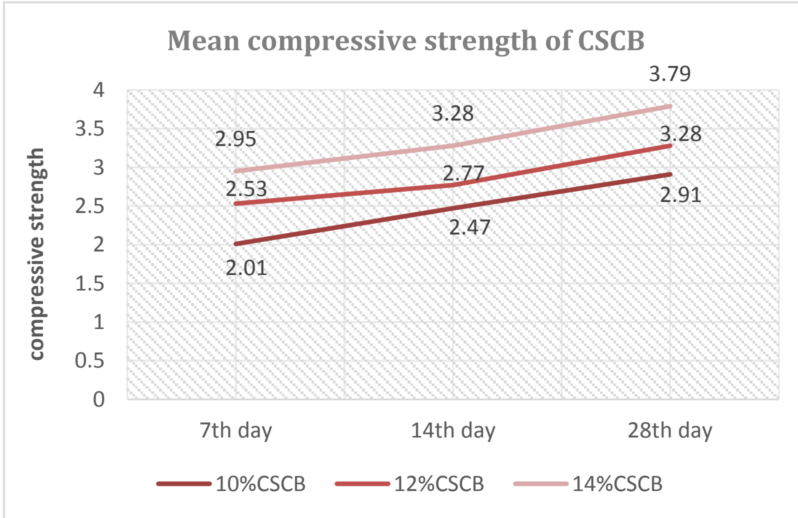

Figure 1. Compressive strength result of CSCB

As shown in the above Figure 1, the compressive strength of cement stabilized clay bricks (CSCB) is increased with increasing of the content of stabilizer on all days of curing period. The compressive strength results showed that the compressive strengths are increasing with the increment of the content of cement from 10% to 12% and to 14%. This indicated that as the content of cement in the mix increases, the bonding of the minerals in clay soil particles also increases that improved the compressive strength.

3.2.3. Compressive strength of lime stabilized bricks

The compressive strength of the 10%, 125 and 145 LSCB were conducted in a similar way with the CSCBs by taking five bricks for each sample at 7th day, 14th day and 28th day of curing time.

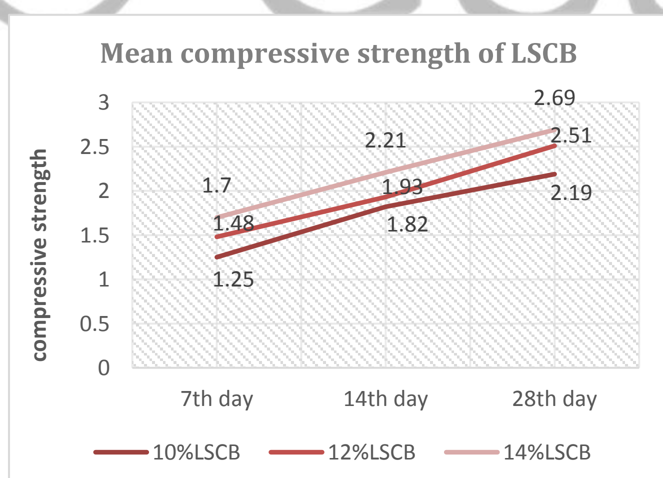

Figure 2. Compressive strength of LSCB

As shown in the above Figure 2, the compressive strength of lime stabilized clay bricks (LSCB) is increased with increasing of the content of stabilizer on all days of curing time. The compressive strength results showed that the compressive strengths are increasing with the increment of the lime content of 10% to 12%, and to 14%. This indicated that as the content of lime in the mix increases, the bonding of the minerals in clay soil particles increases, which has the same performance on the compressive strength with cement stabilizer.

3.3. Comparison of compressive strength of bricks

3.3.1. Comparison of the Compressive Strength of Locally FCB and CSCB

The mean compressive strength result of the fired clay brick is 2.73Mpa, and the compressive strength results of CSCB with 10% of cement are 2.01Mpa, 2.47Mpa and 2.91Mpa at the 7th day, 14th day and 28th day of curing period, respectively. Based on these results, the compressive strength of the fired clay bricks is less than the compressive strength result of the 10% cement stabilized clay bricks at the age of the 28th day of curing period by 0.18Mpa. It can be seen that by stabilizing the clay soil with 10% cement can attain better strength than the locally fired clay brick compressive strength. This means, there is possibility that the brick producers can produce more number of bricks within a short period of time than the traditional way of bricks production. Likewise, the compressive strength with 12% CSCB has a mean compressive strength of 2.53Mpa, 2.77Mpa and 3.28Mpa at 7th day, 14th day and 28th day of curing period, respectively. Again, it showed that at 14th day and 28th day compressive strength results are higher than the locally fired clay bricks. In other words, the 12% CSCB 28th day mean compressive strength is greater than the locally fired clay bricks with mean compressive strength by 0.55Mpa. For the 14% CSCBs, which has compressive strength results of 2.95Mpa, 3.28mpa and 3.79 MPa, it is clearly shown, all stabilized clay bricks are much stronger than the locally fired clay brick which has a mean compressive strength of 2.73Mpa. Extending the curing period at 28th day, the 14% CSCB mean compressive strength is greater than the locally fired clay bricks mean compressive strength by 1.06Mpa. Similarly, with the lime stabilizer, the results indicated the difference in compressive strength of the locally fired clay bricks and the CSCB is increasing as the content of cement for stabilization increased. It means that as the content of cement stabilizer increased the strength of the stabilized clay.

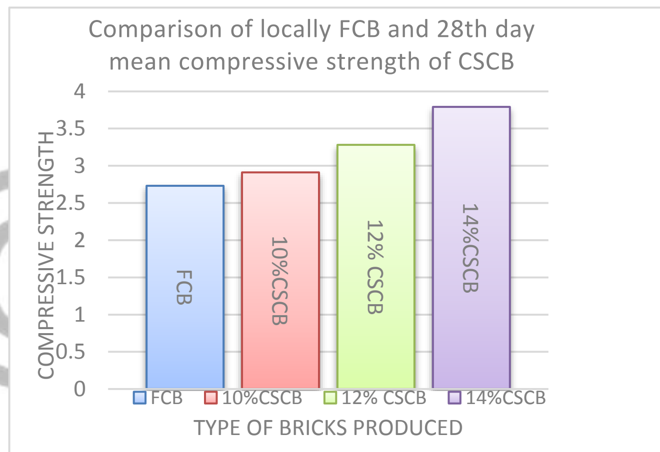

Figure 3. Comparison of compressive strength of LFCB and CSCB

Figure 3 shows the 28th day cured CSCB on the compressive strength, are stronger than the locally fired clay brick with the addition of 10%,12% and 14% cement content of stabilization.

3.3.2. Comparison of the Compressive Strength of Locally FCB and LSC

The results showed the mean compressive strength of 10% lime stabilized clay brick are 1.25Mpa, 1.82Mpa and 2.19Mpa at 7th day, 14th day, and 28th day of testing, respectively. These values are less than 2.73Mpa which is the compressive strength of the locally fired clay brick. The locally fired clay brick mean compressive strength is greater than the 10%LSCB mean compressive strength by 0.54Mpa. The 12% lime stabilized clay bricks of the same curing period indicated the mean compressive strength of 1.48Mpa, 1.93Mpa and 2.51Mpa. Still, these results showed the locally fired clay brick mean compressive strength is higher at 28th day mean compressive strength of 12%LSCB by 0.22Mpa. Likewise, the 14% LSCB has a mean compressive strength value of 1.7Mpa, 2.21Mpa and 2.69Mpa for the 7th day, 14th day and 28th day curing period. In comprison with the later, the locally fired clay brick mean compressive strength is still greater than the 12%LSCB mean compressive strength by 0.04Mpa. As it can be seen from the above results, even though the locally fired clay bricks compressive strength is greater than the LSCBs in all contents, the difference in compressive strength of the locally fired clay bricks and the LSCB is decreasing as the content of lime for stabilization increased. This indicated that as the content of lime stabilizer increased the strength of the stabilized clay bricks was also increased. This is due to the fact that as the content stabilizer increases, the strength of the bond between the soil particles will increase. The performance can be seen in Figure 4 below.

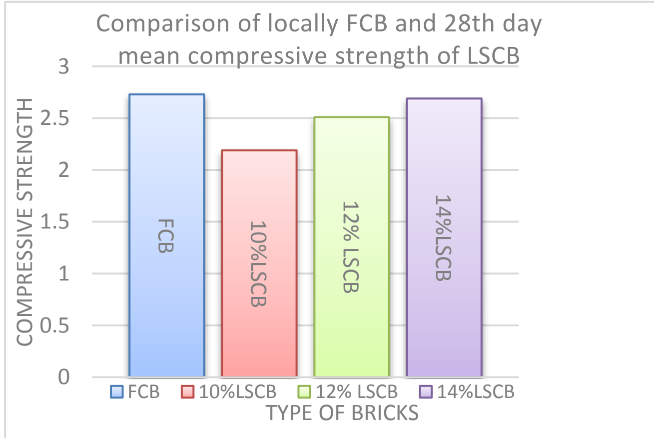

Figure 4. Comparison of compressive strength of LFCB and LSCB

3.3.3. Comparison of the Compressive Strength of CSCB and LSCB

Based on the laboratory test results, all cement stabilized bricks are stronger than the locally fired clay bricks, while all lime stabilized clay bricks are weaker than the locally fired clay bricks. The mean compressive strength results of the 10% cement and lime stabilized clay bricks are 2.01Mpa, 2.47Mpa, 2.91Mpa, and 1.25Mpa, 1.82Mpa, 2.19Mpa respectively at 7^{th} day, 14^{th} day and 28^{th} day curing period. At all ages of curing time, the 10% CSCB has better strength than the 10% LSCB. This showed that cement is stronger stabilizer than lime with 10% content of stabilization. This indicates that the effect of increasing the bondage of clay minerals is higher in cement stabilization than in lime stabilization which was applied by the same amount. The mean compressive strength results of 12% cement and lime stabilized clay bricks are 2.53Mpa, 2.77Mpa, 3.28Mpa, and 1.48Mpa, 1.93Mpa, 2.51Mpa respectively at 7^{th} day, 14^{th} day and 28^{th} day curing. At all stages of curing 12%CSCB is stronger than the lime stabilized bricks. While, the mean compressive strength results of 14% cement and lime stabilized clay bricks are 2.95Mpa, 3.28Mpa, 3.79Mpa and 1.7Mpa, 2.21Mpa, 2.69Mpa respectively considering the same curing period. At all stages of curing 14%CSCB is stronger than the lime stabilized bricks.

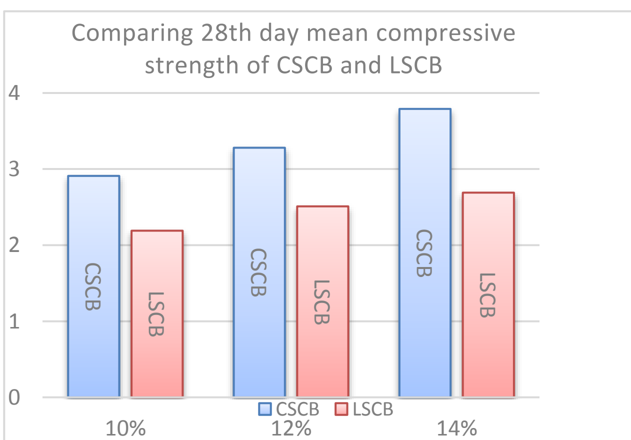

Figure 5. Comparison of compressive strength of CSCB and LSCB

The highest compressive strength obtained in this study was taken at 28^{th} day mean compressive strength of the 14% CSCB, which is 3.79Mpa. While the lime content, the mean compressive strength in each day of curing period, is lesser than the cement stabilized bricks. The chart in the above figure also illustrates these findings. This indicates that the effect of increasing the bondage of clay minerals is higher in cement stabilization than in lime stabilization applied by the same amount.

3.4. Quality tests on FCB and SCB

3.4.1. Absorption of FCB and SCB

For the stabilized bricks, the absorption test was conducted after the 28th day of the curing period. The test could not work for all lime stabilized clay bricks since all the bricks were dissolved in water when they immerse in water for 24hrs.This indicated that the lime stabilized clay bricks gives the bricks low water resistance. This is due to the manual compaction method which does not give the mixture enough bondage during molding. The weak bonding can be easily penetrated by water and the lime dissolved in water. The absorption of the bricks for both the locally fired clay bricks, and 10% CSCB, 12% CSCB and, 14% CSCB have been tested by using five bricks for each sample as per the test method of ASTM C-67. The mean absorption result of the locally fired clay brick was about 15.90%, while the 10%, 12% and 14% cement stabilized clay bricks have mean absorption values of about 14.74%, 14.59% and 13.8%, respectively. The existence of much pores on the surface of the bricks, increased the absorption of the bricks. A brick with higher amount of absorption affects the final built up structure by absorbing much amount of water from the mortar, and resulted in loss of bondage between the bricks. From the above results, the CSCBs showed the lower amount of absorption than the locally fired clay bricks. Even if the burning process more likely gives the clay material, ceramic property, with lower tendency of absorbing water from its surroundings, the cement stabilized bricks revealed better quality of water absorption. This is because the cement is stronger in creating bondage between the particles, and thus minimizing the pores by which the water drains into the brick. Another case, the absorption values of CSCB decreased with the increment of cement stabilized. This indicated that since cement has higher cementing or bonding property, as the amount increased, the absorption will also decrease.

3.4.2. Dimension tolerance of FCB and SCB

The inside dimension of the mold used in this study was the mold used by the local fired clay producer enterprises in Jimma town which was 240mmx120mmx60mm.The dimension tolerance test is the simplest test for all the quality tests of brick. The test conducted on the locally fired clay bricks and all types of stabilized bricks by measuring the dimensions along the length, width and height separately. The average variation (reduction) in (mm) of each type of bricks was compared with the ASTM standard.

Table 4. Dimension tolerance test results of producing bricks [9]

Types of bricks	Average Variation in mm along the length	Average Variation in mm along the width	Average Variation in mm along the height
FCB	24	6.3	5.1
10%CSCB	17.8	3.6	2.4
12% CSCB	16	2.5	2.1
14% CSCB	12	1.7	1.6
10% LSCB	22	4.6	4.9
12% LSCB	19	4	3.6
14% LSCB	18	3.3	2.9

As it can be seen in the table 4, the change in dimension of the locally fired clay bricks are greater than the cement and lime stabilized clay bricks. This indicated that during the shrinkage behavior of the locally fired clay bricks, is higher than the stabilized bricks in all contents. The cement stabilized clay bricks average reduction in dimension are 17.8mm, 16mm and 12mm for the 10%, 12 % and 14% contents of cement as a stabilizer. It is clearly shown that as the content of the cement stabilizers increase, the shrinkage decreases. According to the study of Aime J.F.et al., 2014, this shrinkage happens as the amount of stabilizers increases, the bond between the particles within the paste increase. This increasing of the bond between the particles decreases the shrinkage [9].

3.4.3. Efflorescence

Efflorescence test for all the bricks stabilized with cement and the FCB was conducted According to ASTM C-67. The test was followed after the dimension tolerance test has been accomplished. The result showed all the bricks are not effloresced.

3.5. Comparison of the Compressive Strength of Locally FCB and SCB with different Standards

3.5.1. Comparing locally FCB compressive strength with standards

3.5.1.1. Comparing with Ethiopian standard minimum compressive strength

The minimum compressive strength of bricks corresponding to their classes according to ES 86:2001 are presented in table 5.

Table 5. Minimum compressive strength of bricks [10]

Class	Minimum compressive strength	
	Average of 5 bricks	Individual brick
	N/mm^2	N/mm^2
A	20	17.5
B	15	12.5
C	10	7.5
D	7.5	5.0

The average compressive strength of the locally fired clay bricks is 2.73Mpa. This indicated that it did not fulfill any class Of the Ethiopian standard minimum compressive strength requirements.

3.5.1.2. Comparing with ASTM Standard Specification for Building Bricks (ASTM C-216)

The same as the Ethiopian standard, the FCB in this study did not satisfy the compressive strength, not even close to the value of ASTM standards. The FCB in this study can be categorized as bricks with grade MW which means the bricks subjected to moderate weathering. The value of the minimum compressive strength of five bricks for the moderate weathering type is in ASTM standard is 17.2Mpa which is too much than the average compressive strength of the locally fired clay bricks.

Table 6: ASTM standard of bricks compressive strength [11]

designation	Minimum compressive Strength (Mpa)		Maximum water absorption by 5hr boiling (%)		Maximum saturation coefficient	
	Average of 5 bricks	individual	Average of 5 bricks	individual	Average of 5 bricks	Individual
Grade SW	20.7	17.2	17.0	20.0	0.78	0.80
Grade MW	17.2	15.2	22.0	25.0	0.88	0.90

3.5.1.3. Comparing with British Standard Specification for Clay bricks (BS 3921:1985)

The locally fired clay brick mean compressive strength value of 2.73Mpa did not fulfill the BS class bricks mean compressive strength.

Table 7. British Standard Specification for Clay bricks [12].

No	Class of clay bricks	Compressive strength(N/mm^2)	Water absorption (% by mass)
1	Engineering A	>70	<4.5
2	Engineering B	>50	<7.0
3	Damp-proof course 1	>5	<4.5
4	Damp-proof course 2	>5	<7.0
5	All others	>5	No limit

3.5.2. Comparing locally SCB compressive strength with standards

3.5.2.1. Comparing with Indian Standard Specification for soil based blocks used in general building construction (IS 1725: 1982)

Soil based blocks shall be manufactured from a mixture of suitable soil and ordinarily Portland cement or lime mixture thoroughly mixed together, preferably in a mechanical mixer. The mixture is molded and cast into blocks.

Table 8: Indian Standard Specification for soil based blocks used in general building construction [13]

Classes	Minimum compressive strength
Class 20	20kg f/cm^2 (1.96 Mpa)
Class 30	30 kg f/cm^2 (2.94 Mpa)

The SCB fulfill IS minimum compressive strength requirement of stabilized soil blocks. Except for 12% & 14% CSCB which are under the class 30, but for all SCB are class 20.

4. CONCLUSION

The main objective of this research was to compare the compressive strength of the locally fired clay bricks and the locally stabilized clay bricks with cement and lime, to possibly reduce the deforestation in the study area due to practice of firing the locally fired clay bricks. The stabilization method was undertaken by using Ordinary Portland Cement and lime (hydrated lime) with a content of 10%, 12% and 14% by volume. The results of the index property tests of this study indicated that the soil is A-7 clay soil. The type of soil was determined by AASHTO soil classification system and the contents of the stabilizers were selected as per the class of soil indicated in AASHTO. The plasticity index and shrinkage limit results of the soil indicated that the soil is suitable for brick making. The compressive strength results showed that the cement stabilized clay bricks has better strength than both the lime stabilized and locally fired clay bricks. All LSCB revealed the lesser strength than the locally fired clay bricks. Therefore, cement is a better, stabilizing agent than lime resulting in less variation in dimension after drying and less absorption. All LSCB failed the absorption and efflorescence tests since they all dissolve in water after 24hr of immersion. Stabilizing the clay soil with cement gives better quality bricks. Based on the comparison of the compressive strengths of the bricks with different standards, the locally fired clay brick in this study did not satisfy the minimum requirements of all the standards, but the stabilized clay bricks fulfilled the minimum requirement of the Indian standard (IS). Generally, in addition to saving the environment, stabilizing the bricks with cement is better in both quality and ease of brick production. The producers can get more production within a short period of time by curing than the traditional drying and firing process.

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